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## Analysis of an Eocene Bone-Bed, Contained within the Lower Lisbon Formation, Covington County, Alabama

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ANALYSIS OF AN EOCENE BONE-BED,  
CONTAINED WITHIN THE LOWER LISBON  
FORMATION, COVINGTON COUNTY, ALABAMA

A thesis submitted in partial fulfillment  
of the requirements for the degree of  
Master of Science

By

ANGELA A. CLAYTON  
B.A., Wright State University, 2006

2011  
Wright State University

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ANGELA A. CLAYTON  
2011

WRIGHT STATE UNIVERSITY

GRADUATE SCHOOL

June 3, 2011

I HEREBY RECOMMEND THAT THE THESIS PREPARED  
UNDER MY SUPERVISION BY Angela A. Clayton ENTITLED  
Analysis of an Eocene Bone-bed, Contained within the Lower  
Lisbon Formation, Covington County, Alabama BE ACCEPTED  
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR  
THE DEGREE OF Master of Science.

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## **ABSTRACT**

Clayton, Angela Ann. M.S., Department of Earth and Environmental Sciences, Wright State University, 2011. Analysis of an Eocene Bone-bed, Contained within the Lower Lisbon Formation, Covington County, Alabama.

A fossiliferous lag layer is exposed, at low water levels, next to Point “A” Dam north of River Falls, Alabama. The location of the research site was a coastal region, during the Middle Eocene, and most likely an estuary with complex depositional systems due to the interaction of fluvial and tidal processes. Most of the vertebrate remains at this locality are well preserved and indicate a low-energy environment. The exposure consists of unconsolidated sands rich with Chondrichthyan and Reptilian remains. Little work has been conducted at this location and the exposure was thought to be conformable. With a thorough lithological investigation and systematic sampling it has become apparent that this is not an unconformable exposure but actually displays a discernable interface between the Tallahatta and Lisbon Formations. Furthermore, this area displays distinct characteristics of a macro-to-mesoscopic bone-bed that is exposed for roughly 600 meters along the Conecuh River.

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Thanks to my friends and family for never losing faith, we all know I do things on a different time frame than most.

Finally, thanks to the person I owe the most, Jennifer Soehner, if hadn’t been for your continued support and understanding I believe I would have gone insane. Thank you for always being just who I needed you to be; field assistant, sounding board, proof reader, voice of reason, dog sitter, loving companion and best friend.

## **I. Introduction**

The Point “A” Dam and adjacent spillway allows an extraordinary look at a Middle Eocene bone-bed contained within the Claiborne Group. The exposure is located in Covington County, northwest of Andalusia, Alabama, and extends for roughly 600 meters along the eastern bank of the Conecuh River. The outcrop, along the bank, exposes the upper Tallahatta Formation and lower Lisbon Formation. The bone-bed, which is composed of unconsolidated glauconitic sand with a claystone layer immediately below, is located at the interface of two units and easily accessible at low water levels. This unit features a diverse assemblage of marine fauna consisting of chondrichthyan and osteichthyan teeth and remains, reptile and mammal remains, and unidentified bone material. While the layer above the bone-bed contains trace amounts of invertebrate fossils, the bone-bed itself appears to only host vertebrate remains.

The purpose of this research project is five-fold; (1) critically examine the previous lithological description of the research site, and to use sedimentary cores, thin sections, and site analysis, to reclassify and re-describe the formation; (2) describe species abundance and diversity; (3) discuss depositional environment and paleoecology of the research site; (4) examine basic sequence stratigraphy patterns at the research site; (5) examine the exposure to define the lag layer as a bone-bed.

## II. Background

The research site for this project is located at Point “A” Dam in Covington County, Northwest of Andalusia, Alabama (Figure 1). The specific research site is located within NW1/4, SW1/4, Section 35, T5N, R15E (River Falls Quadrangle Topographical map, 7.5 minute series [Holman, 1988]). At this location, the upper-most part of the Tallahatta Formation and the lower-most part of the Lisbon Formation are exposed. Both units are contained within the Claiborne Group. The Lisbon Formation is a loosely to non-consolidated glauconitic, fossiliferous, non-calcareous, muddy sand ranging in thickness between 20 and 40 meters (Mancini, 1994). Typically, the Lower Lisbon is white to light greenish grey siliceous material that is interbedded with thin layers of clay and sandy clay. The formation is an exposed belt that extends westward from Georgia through Alabama and into Mississippi (Savrda, 2004). The sandstones of the Lisbon are distributed throughout Covington, Conecuh, Monroe, Clarke, and Choctaw counties in Alabama (Figure 2). The Tallahatta Formation is a white to very light-greenish-gray thin-bedded to massive siliceous claystone; interbedded with thin layers of fossiliferous clay, sandy clay, and sandstone. White to light-greenish-gray fine to coarse sand and fine gravel occurs at the base of the formation in southwest Alabama (Meridian Sand Member). The Claiborne Group represents a relatively shallow passive shelf environment that existed during the Middle Eocene in this part of Alabama (Smith, 1979). The depositional record shows evidence of several transgressive events.

During the Early to Middle Eocene (55.8-40.4 Ma) a sharp rise in temperatures occurred which caused a relative rise in sea level. The Claiborne Group is the product of a transgressive systems tract, at a passive-margin shelf setting, caused by a thermal

maximum and subsequent melting of glaciers (Ivany, 1998). The oceans, during the Eocene, were host to a wide array of sea life, including the first appearance of marine mammals, the introduction of the Carcharinid sharks, and a large increase in sea snakes and reptiles (Gunnell, 2001).

The sequence stratigraphy of the research site was examined and as a precursor to the topic, below is a brief description into the basics of the subject.

The broad purpose of sequence stratigraphy is to relate depositional and erosional events to cyclic changes in sea level rise and fall, and to divide sedimentary deposits into sequences that are bounded by unconformities (Emery, 1996). In the framework of stratigraphy, these boundaries and sequences result from changes in sea level, accommodation space and sedimentation rates, and allow chronostratigraphy and lithostratigraphy to be combined via the processes of sedimentation and erosion (Catuneanu, 2006). The understanding of these processes lends insight into the depositional events that occurred during sedimentation. Sequence stratigraphy has revolutionized the analysis of how sedimentary deposits have formed and how the nature of deposition has changed through time. A brief description of sequence stratigraphic terms and processes follows.

### *Parasequences*

A parasequence is defined as a relatively conformable succession of genetically related beds or bed-sets bounded by marine flooding surfaces and their correlative surfaces (Coe, 2003). Parasequences shallow upward and this represents an episode of progradation, the seaward movement of a shoreline. Parasequences typically occur in sets with patterns in the way that they stack. The three stacking patterns that

parasequences exhibit are progradational, aggradational, or retrogradational (Coe, 2003). As parasequences build out or advance seaward a progradational stacking pattern is formed. In this case, each parasequence exhibits a shallower depositional environment than the previous para-sequence. This is due to accommodation space being exceeded by the sedimentation rate. In an aggradational stacking pattern there is a lack of change in rate of sedimentation. Each parasequence exhibits relatively the same depositional environment as the previous parasequence. As parasequences show a pattern of deepening or a retrogradational stacking pattern is formed. In this case the accommodation space exceeds the sedimentation rate (Coe, 2003).

### Depositional Sequences

A depositional sequence is a relatively conformable succession of genetically related strata bounded by unconformities or their correlative conformities. Each depositional sequence is the record of one cycle of relative sea level. Each sequence is composed of the following units; *sequence boundary*, *lowstand systems tract* (LST), *transgressive surface*, *transgressive systems tract* (TST), *maximum flooding surface*, *highstand systems tract* (HST) and sequence boundary (Coe, 2003).

The first unit is the *sequence boundary* which is generated by a relative fall in sea level and is commonly marked by a regression. Following the sequence boundary is a unit that results from a period of low sea level which is known as the *lowstand system tract* (LST). The LST can be composed of the lowstand fan (aggradational stacking) which is overlain with the lowstand wedge (progradational stacking) (Catuneanu, 2006).

During this time relative sea level begins to rise very slowly. The *transgressive surface* (TS) caps the LST and during this time relative sea level rises at an increasing

rate. Following the TS is the *transgressive systems tract* (TST) which is characterized by retrogradational stacking. During this time there is a long-term rise in relative sea level and the accommodation space continues to grow faster than the sedimentation rate. The *maximum flooding surface* (MFS) marks the transition from retrogradational stacking to aggradational or progradational stacking (Figure 5). This unit is recognized by the deepest water deposits and the farthest landward extent of the deep water facies. Lastly, the *highstand system tract* (HST) marks the shift from an aggradational to progradational stacking pattern. During this time the relative sea level rise slows and then it begins to fall before the next sequence boundary. During a HST the erosion of sediment is most prevalent; however erosion also occurs throughout the LST (Coe, 2003).

#### Sequence Stratigraphy Interpretation of the Alabama Coastal Plain

The geology of the Alabama coastal plain is representative of a transgressive event during the Early to Middle Eocene. A transgressive event denotes a relative rise in sea level. More specifically, a transgressive event is a landward migration of the shoreline up and to the point that sediment accumulation exceeds accommodation space available for deposition; at which point a regressive event occurs. If space for sediment accumulation becomes greater than the sediment supply another transgressive event will occur. Transgressive events tend to preserve less sediment than regressive events because shorelines are eroded. Previously deposited sediments are removed, often forming an unconformity (Figure 4). In a regressive event, sediment is preserved at a greater rate than in a transgressive event (Catuneanu, 2006). A regressive event will generally be recorded as a coarsening upward of sediments. These events (transgressive/regressive) are typically cyclic. Sediment is supplied to shorelines by rivers and oceanic currents.

The space for sediment, or accommodation space, is generally governed by sea-level changes that are affected by tectonic or climatic changes (Catuneanu, 2006).

At roughly 55 Ma, the earth experienced a large increase in CO<sub>2</sub> levels which subsequently lead to the warmest period of the last 100 million years (Schmitz, 2007). This abrupt thermal change caused increased sea levels, coastal plains with moderate width rivers to be replaced with braided channels and increased sediment influx (Schmitz, 2007). The transgressive events evident at the Point “A” dam are likely an indirect result of these climatic changes. The lag layer identified in this study was a product of an estuarine environment.

Chondrichthyes and bony fish are the main macroscopic vertebrate remains found at the research site. Chondrichthyes include the subclass Elasmobranchii which comprise sharks (Selachii), skates and rays (Batoidea), and the chimaeroids (Holocephaleans) (Figure 3). The elasmobranchs have a cartilaginous skeleton, an upper jaw that is not fused to the braincase and encompass about 600 various species. They can be heterodontic, have the ability to continually replace teeth (up to 3000 in a life span) and exist in varying ecological settings. They have low reproductive rates and a lifespan of roughly 20 – 25 years. Most often their remains can be found in fossiliferous bone-beds or lag layers (Allen, 1999).

By definition, a bone-bed is the preservation of any vertebrate hard parts from two or more individuals that reside in close ecological proximity. The single sedimentary strata must have a more dense concentration of bone material than the surrounding strata both vertically and horizontally (Rogers, 2007).

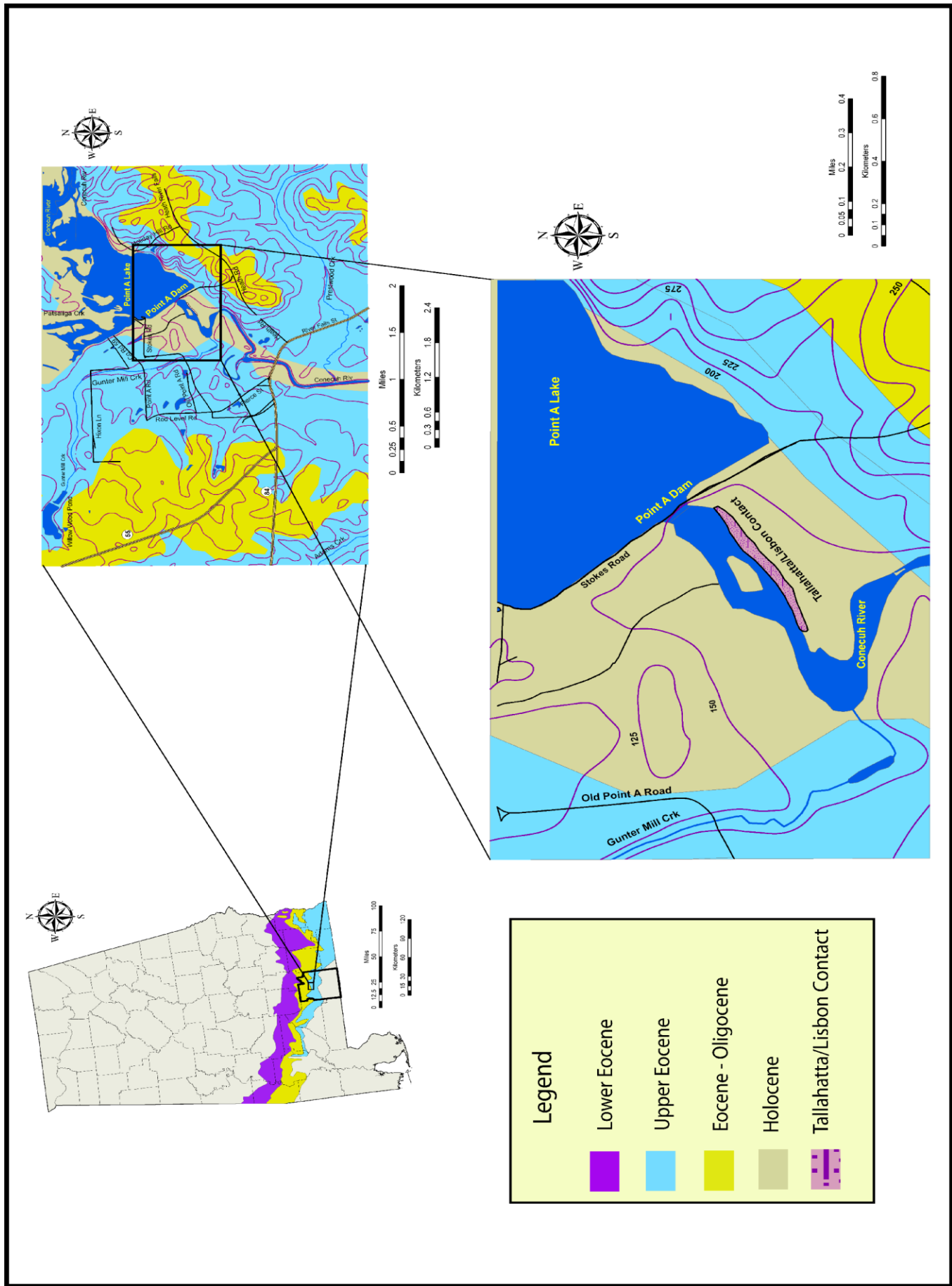


The research site, located at Point “A” Dam, has been previously examined by Case (1988) who focused primarily on the reptilian fauna and ignored the chondrichthyan and bony fish fauna. Furthermore, Case failed to examine the lithology and sequence stratigraphy represented at the site and classified this locality as the Tallahatta Formation. Upon further investigation, it has become clear that this site was misclassified and more closely reflects the lowermost Lisbon Formation. Examination of sediment cores and thin section during the course of the project confirm this lithological identity. Additionally, little has been written on the fossil-rich layer itself. It is the intention of this project to provide evidence that defines this fossil-bearing sand as a bone-bed, found within the basal portion of the Lisbon Formation, unconformably overlying the uppermost Tallahatta Formation.

Much of the surface and sub-surface geology of the northern part of Alabama has been systematically mapped, cored and described. However, the southern-half of the state, the Coastal Plain has been largely ignored because it is not a hydrocarbon-producing region. This has led to confusion concerning formation boundaries and sequence stratigraphic relationships, especially with regard to Eocene-age strata. Many of the Eocene and Oligocene units within the coastal Plain lack formal definition and description. Much of the literature produced by the Geological Survey of Alabama groups the Tallahatta and Lisbon into a single unit or combines the two into the Claiborne Group. Upon closer investigation, the findings show that at very low water levels, the uppermost part of the Tallahatta Formation and the lowermost Lisbon Formation are exposed at Point “A” Dam, within the banks of the Conecuh River, at River Falls, Alabama. The bone-bed, or lag layer, that is the focus of this research, lies

unconformably above the uppermost ichnofacies clay layer of the Tallahatta Formation and is, in fact, the lowermost exposed portion of the Lisbon Formation.

Many localities in southern Alabama are well known for their fossil-rich vertebrate remains. One such location is Stave Creek located in Clarke County, Alabama. This location is widely known for its rich shark-tooth fauna from the Eocene. This stratigraphic unit is part of the Gosport Sand Member of the Lisbon Formation and is only exposed for a short lateral distance in Stave Creek. The lower 0.3 meters of the unit is where the fossil rich concentration of shark teeth is found. Although never connected to the unit of interest in this research, the layer exposed at Stave Creek may be its lateral continuation.





## Alabama Counties

Produced by the Dept. of Geography  
College of Arts and Sciences  
The University of Alabama

**Figure 2.** Approximate extent of the Lisbon Sandstone within Alabama.

# Elasmobranchii

Sharks



Rays



Skates



Chimaeras

**Figure 3.** Pictures of shark, skate, ray and chimaeroid; examples of the Elasmobranchii subclass.

### III. Methods

Fieldwork was conducted to collect bulk samples of the Point “A” Dam bone-bed to examine and categorize species diversity and abundance. This collection was performed at three locations; sites “X” “Y” and “Z” (Figure A.1), along the bank of the Conecuh River, near River Falls, Alabama. Sites were selected based on the expanse of the exposed layer. The initial collection site, “X”, is located at the northern-most extent of the outcrop (Figure A.2). The bulk of the sediment was shoveled into nested sieves (0.125” and 0.033”) and rinsed over a bucket using water. The sediment that passes through the sieves was collected, bagged and brought to a laboratory to be sorted and categorized under a microscope. Additionally, a portion of the raw sediment was brought back to a laboratory for analysis.

The bone-bed is exposed for 600 meters and collections were made at three locations along this exposure. A GPS unit was used to log the exact locations of collection:

	Latitude	Longitude
Site X	31.359281	-86.519598
Site Y	31.358868	-86.520317
Site Z	31.358378	-86.521518

**Table 1.** Latitude and longitude for research sites.

Reconnaissance and sediment sampling were performed on four separate occasions to sample as much of the bone-bed as possible, to ensure a true representation of the faunal diversity and to determine the optimal locations to gather stratigraphic

analysis and core samples. Photographs were taken of the collection sites and the bone-bed layer. A vertical sediment sample was taken at 30 cm intervals spanning the largest vertical exposure (Figure A.3). A two gallon graduated bucket was used to ensure equal collection amounts at each segmented interval. The samples were bagged immediately and processed for vertebrate fossil remains in the laboratory. Additionally, sediment cores were taken from localities “X” and “Z” (Figure A.4). The purpose of the stratigraphic coring was two-fold: 1) to determine the vertical extent and changes in the concentration of vertebrate remains above the bone-bed; and 2) to determine the position of the Tallahatta/Lisbon Formation boundary and the position of the bone-bed. Ultimately the cores were used to classify the formation’s lithological content and thus to determine whether the bone-bed forms the top of the Tallahatta Formation or the bottom portion of the Lisbon Formation.

To collect each core, a 61 cm long and 38mm diameter PVC pipe was driven into the sediment using an 8 pound sledge hammer. The core was then vertically dug out of the bank to ensure that it remained intact and accurate in representing true in situ position. Once removed, the cores were marked top and bottom and the ends were sealed and then taped. Back at the laboratory, the cores were dried and injected with a low viscosity epoxy (Buehler’s Epo-Thin, diluted with 25% absolute ethyl alcohol). The hardened cores were then cut at 11.5 cm intervals and made into thin sections and photographed to show compositional grain distribution. Six thin sections were prepared starting at the top of the core (furthest from the bone-bed) and terminated in the clay layer.

Species abundance and diversity was determined by counting and classifying the chondrichthyan fauna found within the bone-bed. All identifications were made to at least the genus level. The samples were separated according to taxonomic rank using literature found in *A Pictorial Guide to Fossils* (Case, 1992), *Handbook of Paleoichthyology Chondrichthyes II*, *FAO Species Catalogue* (Compagno, 1994), *The Shark Almanac* (Allen, 1999) and *Handbook of Paleoichthyology; Chondrichthyes II Mesozoic and Cenozoic* (Cappetta, 1987).



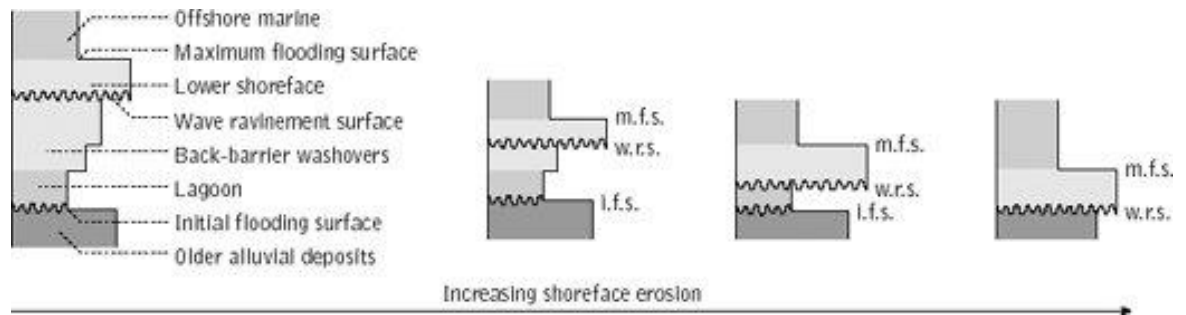
#### IV. Sequence Stratigraphy

The sequence stratigraphy for the Middle Eocene Claiborne Stage encompasses a single supercycle in sea-level change (Ivany, 1998), i.e., it is comprised of marine sands and silts deposited in an open shelf setting. Within the supercycle of the Claiborne Stage, four third-order sequences are contained within the Tallahatta and Lisbon Formations (Ivany, 1998). The third-order sequences are separated by Type II unconformities identified by richly burrowed surfaces (ichnofacies). Additionally, each ordered sequence exhibits the characteristic transgressive, condensed, highstand deposits of a standard depositional sequence (Figure 5) (Emery, 1996).

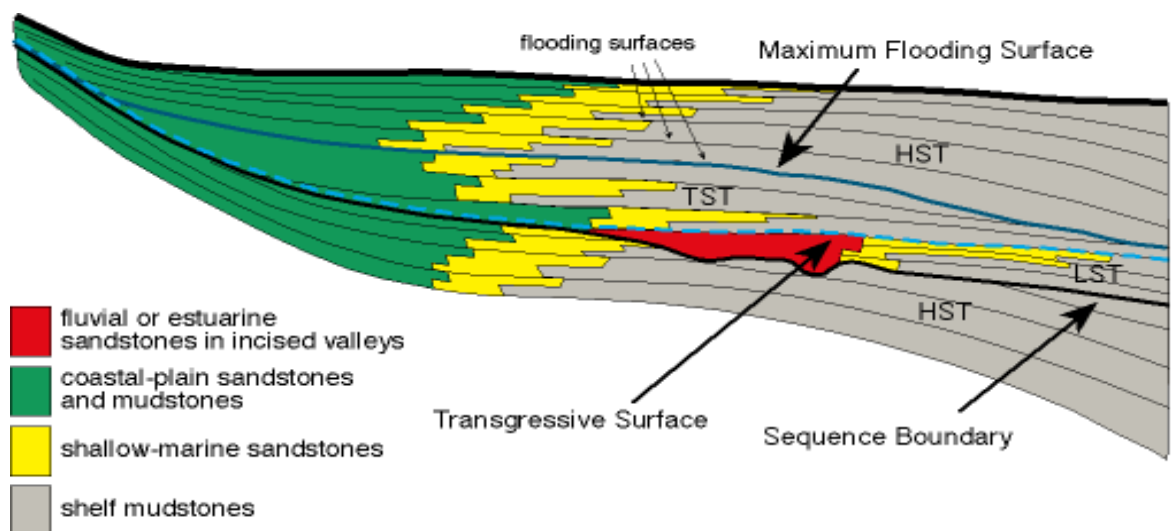
##### Claystone Ichnofacies and Glauconitic Sands

The upper-most section of the Tallahatta Formation at Point “A” Dam shows that the highly bioturbated layer (Figure 6) exposed at low water levels is composed of siliceous mudrock with hardground burrows and intergenic traces on bed soles (Savrdá, 2010). The claystone or mud rock is overlain by coarse, unconsolidated, glauconitic sand. The glauconite, present in the unconsolidated sand, is most likely a transformation of terrestrial detrital clays, such as kaolinite, in a water environment (Harder, 1980). Glauconite forms when the element Fe substitutes for Al during transformation large amounts of K and SiO<sub>2</sub> are introduced. However, these elements are not found in any one environment. The iron and silica content of sea water is too low for the formation of glauconite and the lack potassium content in fresh river water prevents the formation of glauconite (Meunier, 2007). Therefore, the formation of glauconite can not originate from normal marine or fluvial source independently (Harder, 1980). This would suggest an infiltration of the two environments to create the appropriate conditions for the

formation of glauconite. Additionally, the high silica concentrations necessary for the formation of glauconite indicates a strong terrestrial sediment input.



**Figure 4.** Generic transgressive sequence showing shore face erosion by waves and thus unconformities. (Figure adapted from Carter, 1994)



**Figure 5.** Depositional Sequences. (Figure adapted from Van Wagoner 1990)



**Figure 6.** Bioturbated layer comprised of siliceous mudrock.

## **V. Formation Identification**

In previous studies by Holman, A.J., and Case, G.R., in 1988, the research locality along the Conecuh River, exposed at River Falls, Alabama, was classified as the Tallahatta Formation. Upon further investigation, the exposed formation more accurately correlates to the Lisbon Formation. In fact, at low water levels, the contact between the Tallahatta and Lisbon formations is exposed. The bone-bed/pebble lag is above an unconformity that separates the Tallahatta and Lisbon formations. The Tallahatta Formation has been formerly described as grey sandstone with some glauconite and concretions of white clay, streaked with yellowish iron oxide concretions. It is considered hard and resistant to decay with shell impressions and strongly burrowed with trace fossils. The Lisbon Formation is generally finer grained, with a more uniform texture, and copious amounts of glauconite. It is largely unconsolidated and highly fossiliferous. (Adams, 1979). Most literature sources define the two formations as conformable and lacking any definable boundary, however, at low water levels at Point “A” Dam, the interface of the two formations is clearly defined. It is also here that the depositional lag layer is found (Figure 7).

The heavily burrowed white clay pan of the uppermost part of the Tallahatta and the highly glauconitic unconsolidated blue-green sands of the Lisbon Formation are visible. The two formations show neither coarsening nor fining upward. The glauconitic sand is homogenous throughout. The white clay, heavily bioturbated layer, is indicative of the Tallahatta Formation (Figure 8) (Savrda, 2005). Note that the “white” part of this layer is only visible when scrapped, as the very top portion when exposed to air is quickly oxidized to a brownish rust color.

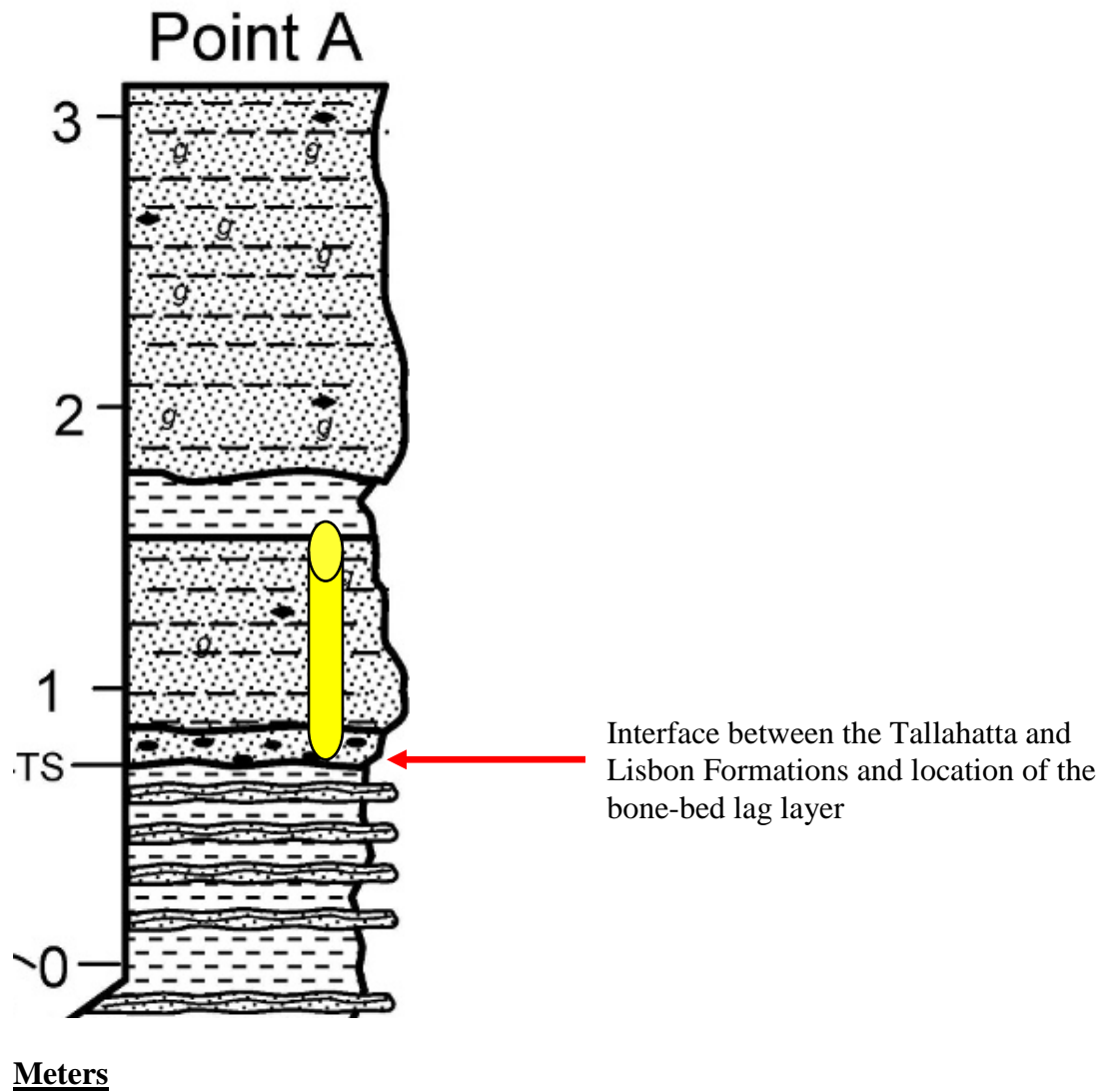
A core (Figure 9) was collected and analyzed to show the lithological structure of the interface of these two formations: Thin sections 1-6 (Figures 10-15) show the loosely consolidated glauconitic sands of the Lisbon underlain by the hard packed clay of the Tallahatta.

The top of the lithological core is shown in thin section (Figure 10), as is the bottom of the lithological core, which represents the uppermost bioturbated clays of the Tallahatta Formation (Figure 15). The sediments found in the core are predominately medium to coarse siliciclastic grains and bioclasts. The grey and white grains, shown in the slides, are quartz, while the dark and light green grains are glauconite and the black grains are phosphate and bioclasts. The background matrix is mud. The core is representative of the formation contact exposed at all three locations of the research sites. The matrix is unconsolidated and thus has no cementation history. Thin section #1 (Figure 10) is predominately organic soil with scattered quartz grains. This slide was taken at the uppermost section of the core and contained little to no part of the actual formation. Thin sections #2 - #5 (Figures 11-14) contains largely all bioclasts, phosphate, quartz and glauconitic sands; these components are representative of the lower Lisbon formation. Thin section #6 (Figure 15) is almost void of the grains of #2 -- #5 (Figures 11-14) and is solely comprised of clay and clay sized particles. This thin section (6) (Figure 15) is indicative of the uppermost portion of the Tallahatta Formation.

While the analyzed core represents a single sampling of the exposure, it is representative of what was observed at the exposure along the Conecuh River, at the Point "A" Spillway. Previous literature has grouped the two formations together and regarded them as conformable because the two formations are nowhere else as clearly

exposed and delineated as they are at the Point “A” spillway (Figure 16). Erosion at this location has exposed the units such that the contact is visible at low water levels. The observation of the exposure and the analysis of the thin sections, provide the evidence to support the stark lithological change found at this locality which defines the two formations as independent units.

Additionally, the distribution of glauconite throughout the Lisbon Formation, including the bone-bed, indicates that the glauconite was formed in situ and after deposition as a function of diagenetic processes. Had the formation of the glauconite occurred prior to deposition, the mineral would have been in greater concentrations in the bone-bed much like the vertebrate material had been condensed.



**Figure 7.** A generalized stratigraphic column showing the coring location as well as the bone-bed layer.

TS = Transgressive surface

G = Glauconitic sands

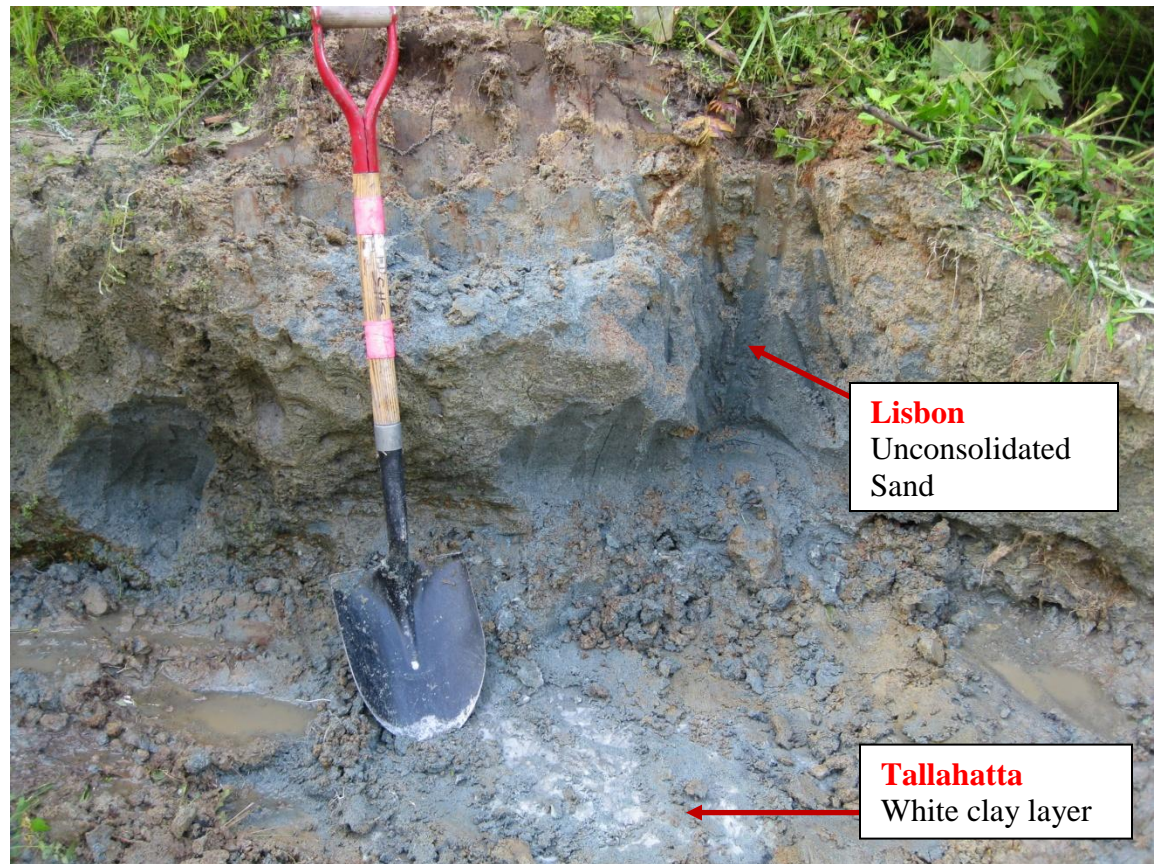
--- = Clay (mudstone)

● = Fossils



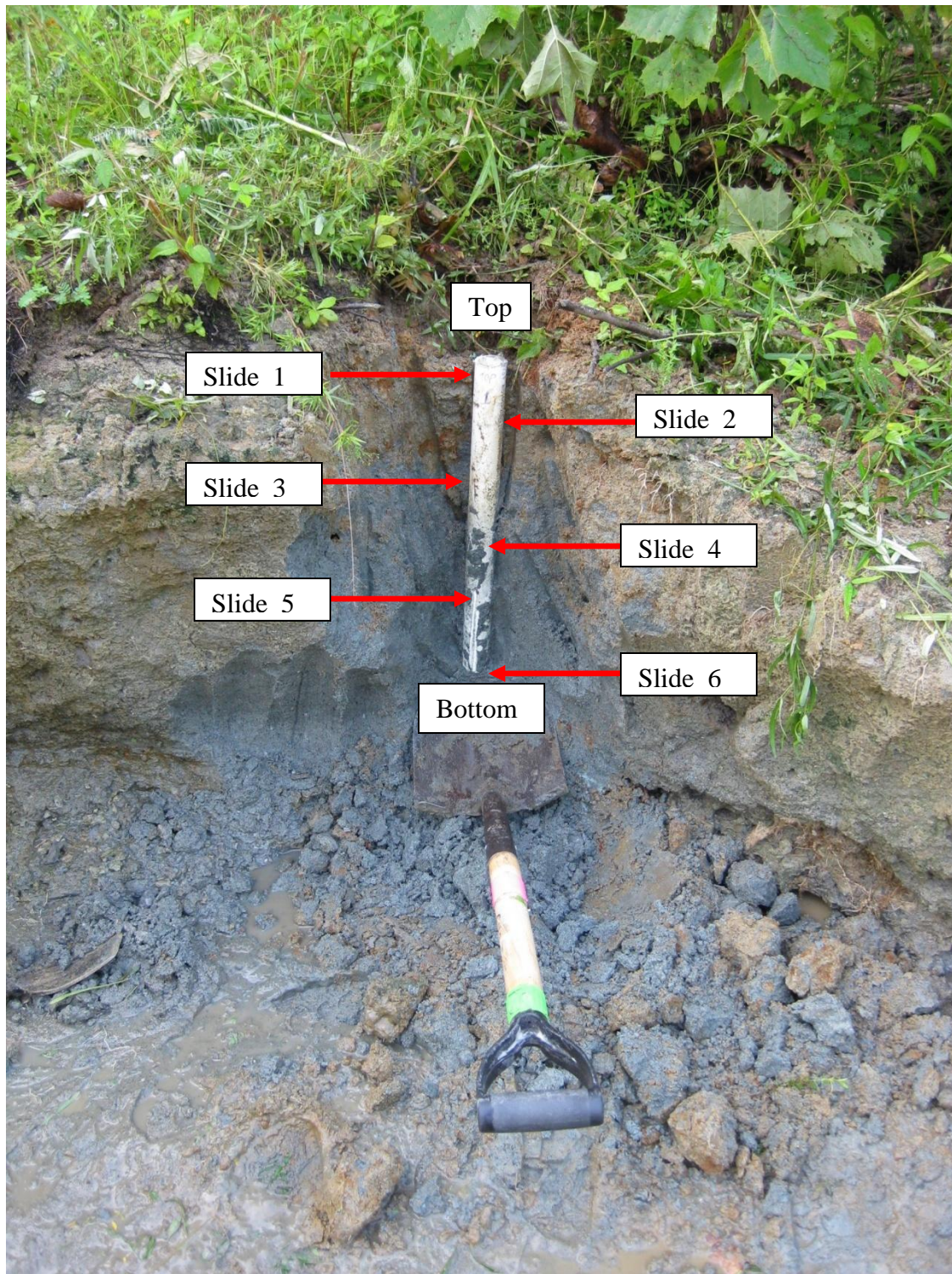
= Core sample





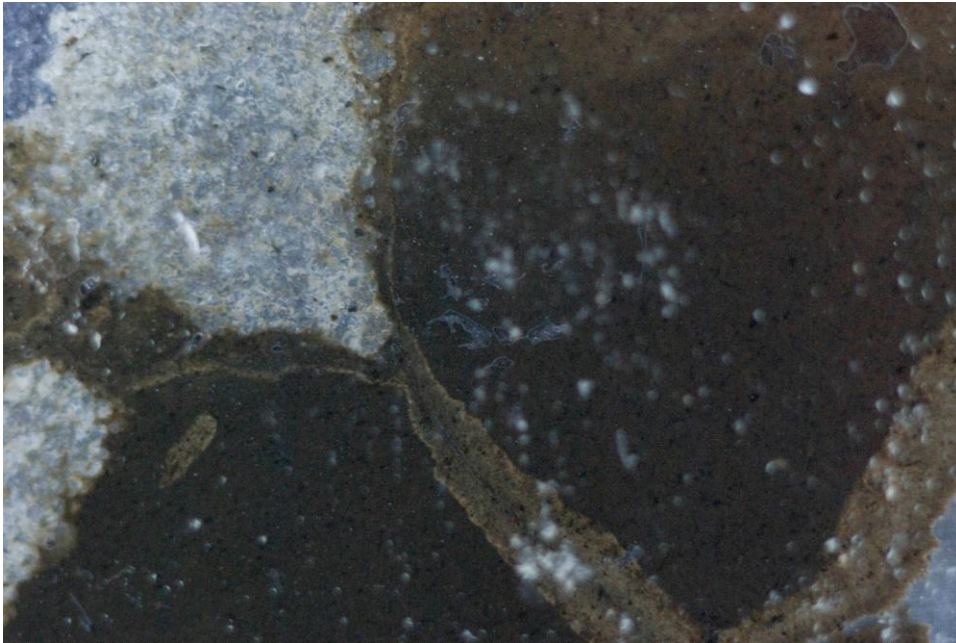
**Figure 8.** Tallahatta and Lisbon formation contact exposing the white clay layer of the Tallahatta formation and the unconsolidated sands or the Lisbon.



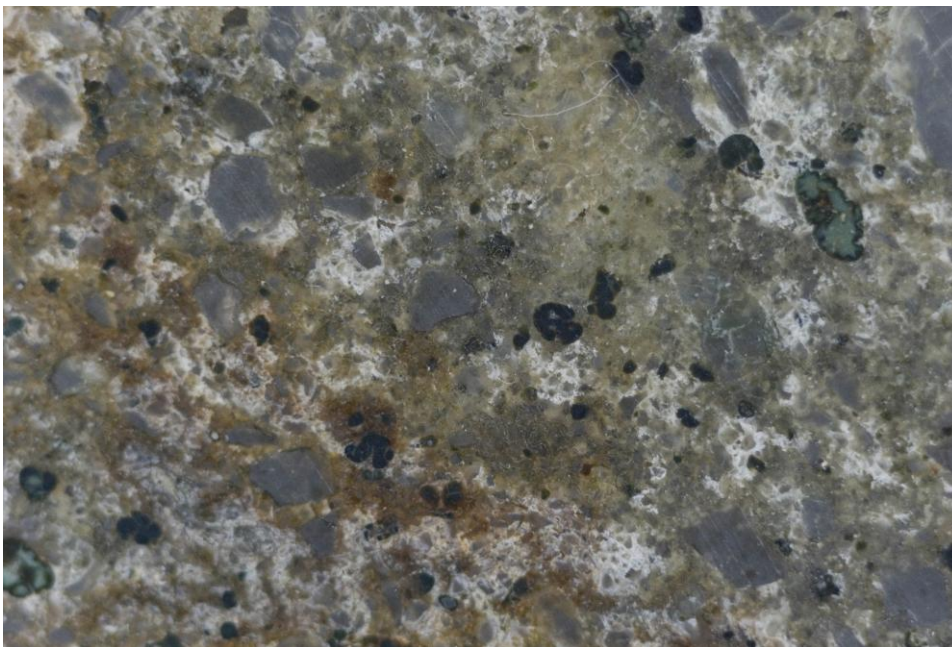


**Figure 9.** Core prior to removal

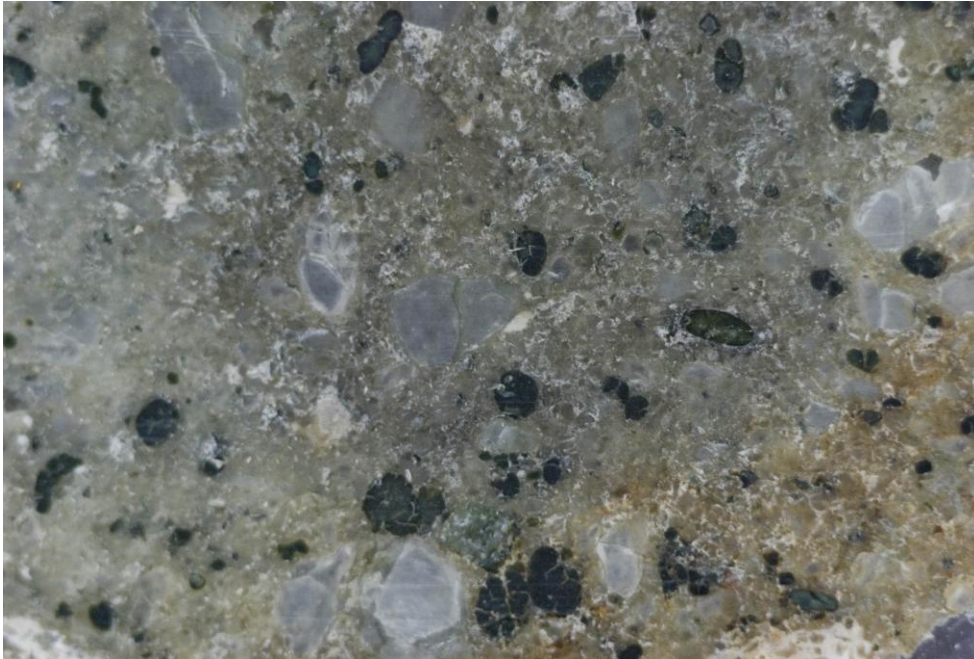




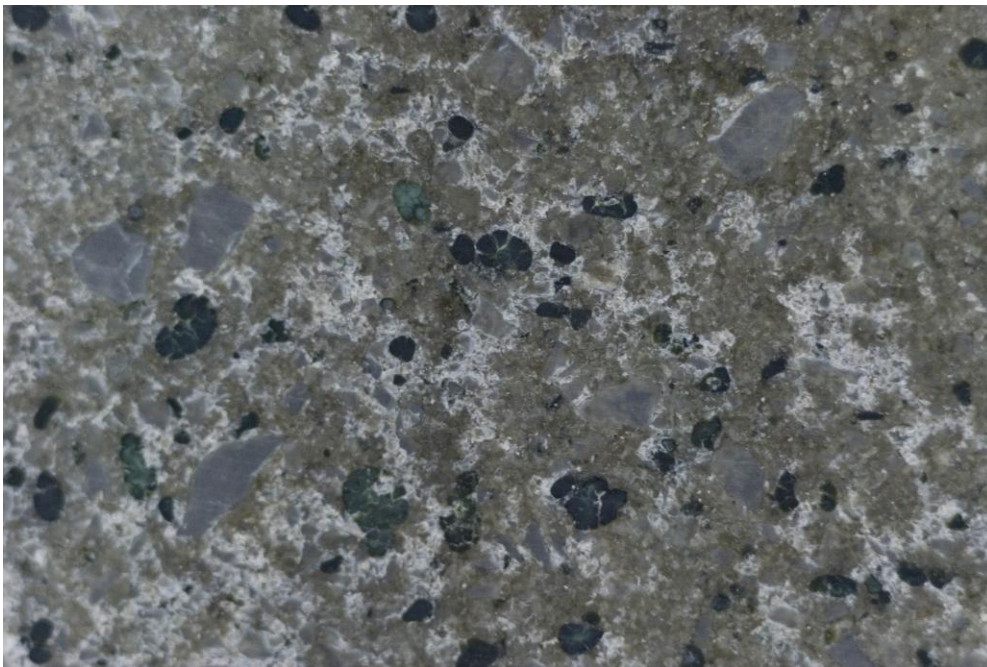
**Figure 10.** Thin section #1: Organic material and mud with a small amount of quartz.



**Figure 11.** Thin section #2: Some mud/organic material, dominantly quartz with glauconite and phosphate pebbles.

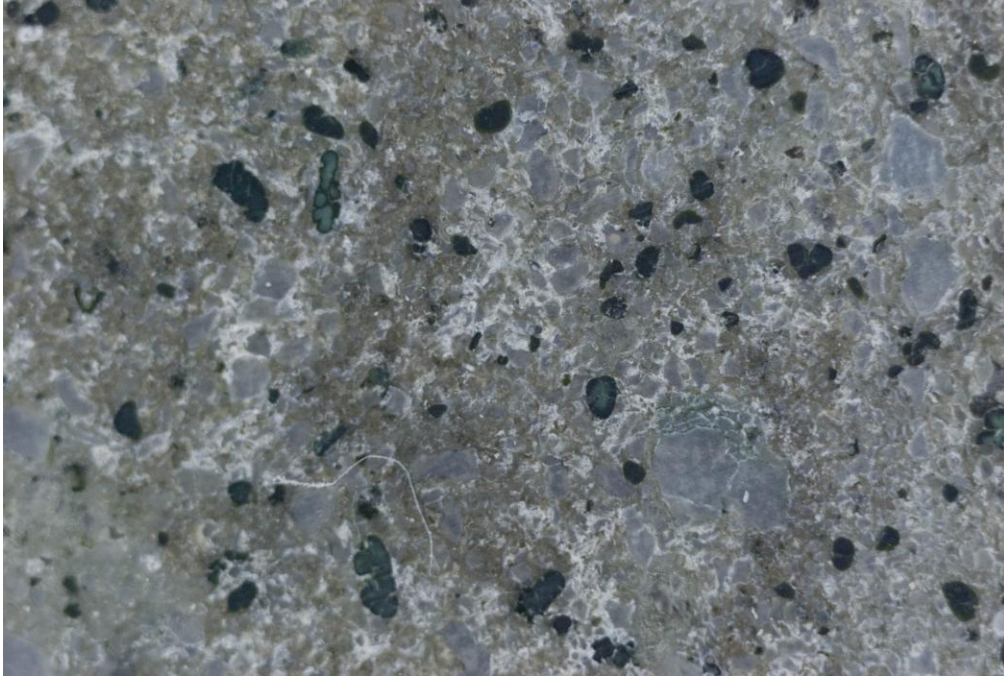


**Figure 12.** Thin section #3: Very little mud and mostly quartz, glauconite and phosphate



**Figure 13.** Thin section #4: Phosphate grains and mainly quartz with some glauconite.

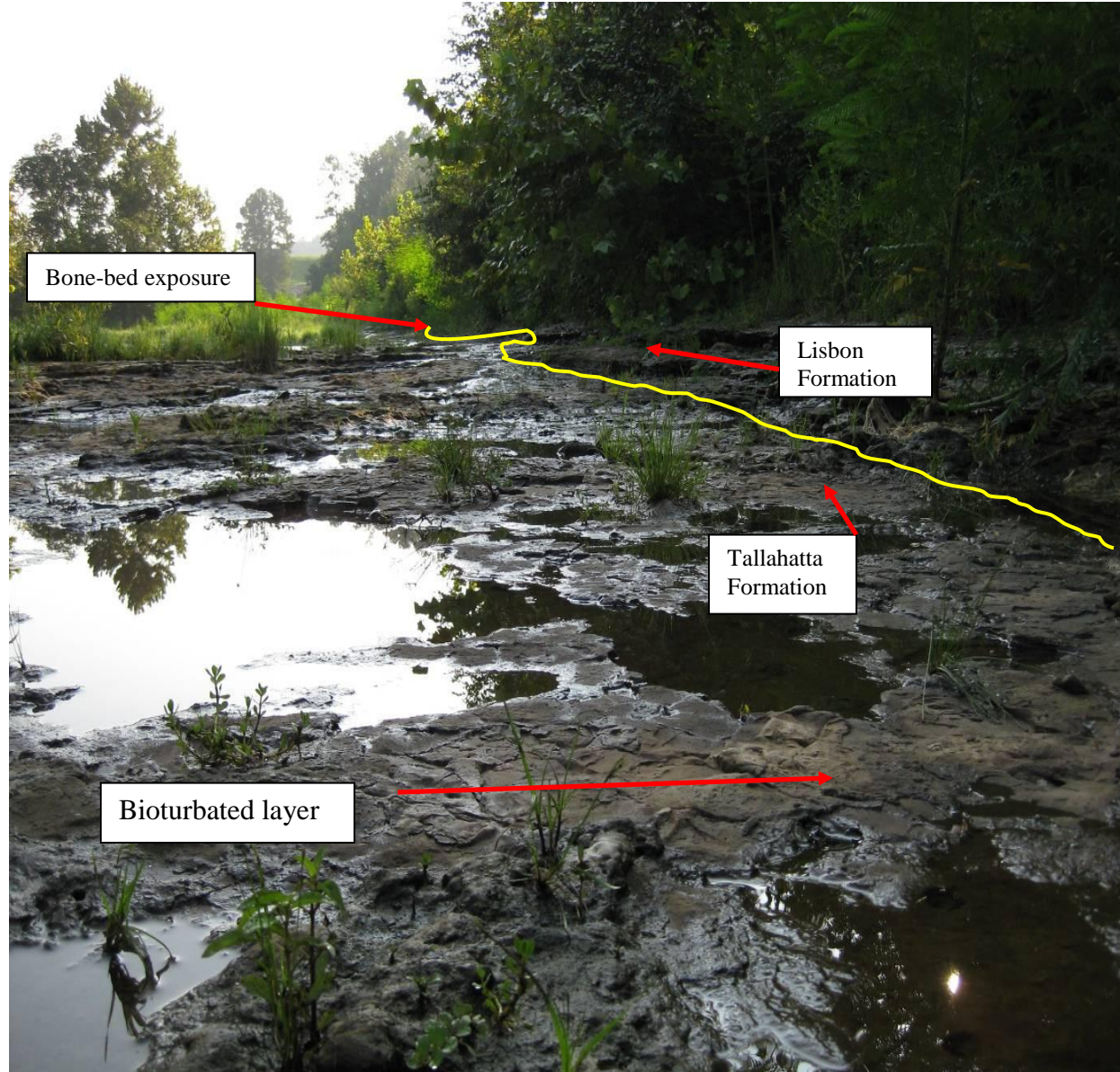




**Figure 14.** Thin section #5: Quartz, Glauconite and some phosphate.



**Figure 15.** Thin section #6: The ichnofacies layer made of clay and mudstone.



**Figure 16.** Low water level exposure at Point "A" Dam looking northward.

## **VI. Depositional Environment**

During the Eocene, south-central Alabama was a shallow coastal marine environment; analysis of both fossil fauna and physical lithology support this fact. The Gulf Coastal region of Alabama is predominantly composed of glauconitic quartz sands and clay (Bybell, 1985). These lithological components support the interpretation that 50 million years ago this area was a shallow tropical sea. Additionally, the heavily bioturbated layer found in the uppermost exposure of the Tallahatta Formation indicates that this region included a low energy environment and supported organisms that required sedentary conditions within which to feed (Urash, 2004). Furthermore, the fossil assemblage found at this locality comprises organisms that are shallow to mid-shelf marine dwellers.

A comprehensive collection of marine vertebrate fossils was gathered from the bone-bed exposed at the research site. The bone-bed represents a lag layer deposited during a transgressive event and contains a large amount of faunal diversity. Additionally, the burrowing organisms, found on the muddy ocean floor, increased the preservation of these fossils; by creating burrows, teeth and other hard parts became lodged in the burrows and aided in their preservation. Most of the specimens retrieved from this locality are in excellent condition and show very little reworking or abrasion. This indicates that the vertebrate remains were deposited during a transgressive event which created a transgressive surface and likely experienced little to no reworking after deposition. The bone-bed was deposited in a relatively low energy environment with intermittent storm occurrences (Tew, 1992).



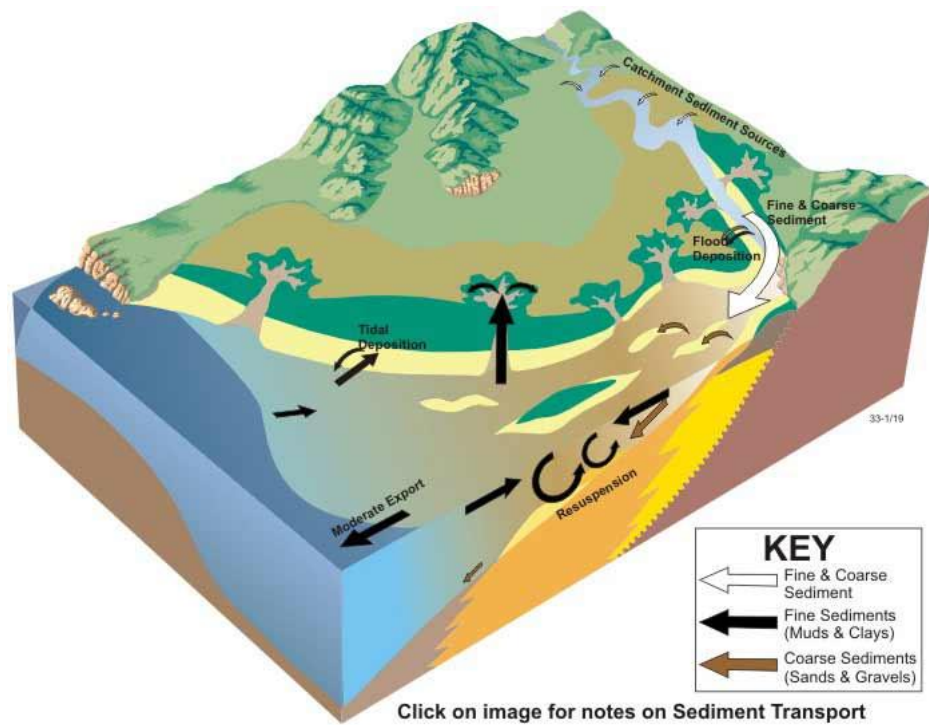
The environment, at time of bone-bed deposition, was most likely an estuary, which commonly forms during a retrogradational or transgressive succession (Nichols, 1999). An estuary is a location where fresh-water from rivers and salt-water from oceans intermingle. In an estuary the mouth of a river will experience an influx of salt-water and subsequent tidal processes. As the tides rise and fall, tidal channels are created (Figure 17). Tidal currents in these channels can carry and deposit sediment rich in bioclasts (vertebrate remains) which drop out of suspension and create lag layers (Figure 18) (Nichols, 1999).

The presence of fragments of crocodile and turtle (marginal marine organisms) remains that were found during the sampling process suggests that the environment of deposition was near shore.





**Figure 17.** Example of tidal channel in an estuary.



**Figure 18.** Sediment transport in estuaries.

## **VII. Diversity and Abundance**

The species diversity and abundance of all vertebrate fauna was tabulated from the collection of remains from all three research localities seen in Table B.1. and Chart 1 (Figure 19). The remains represent primarily selachians (sharks and rays), bony fish and crocodilians. In general, the majority of the specimens found typically inhabit shallow water communities.

Selachians represent the largest portion (15:1) of the remains recovered. This may be due, in part, to the fact that sharks generate and lose up to several thousand teeth throughout their life time. The total abundance numbers may be positively skewed since it cannot be determined how many individuals are represented. This is a common problem when studying sharks since their skeletons are cartilaginous and very rarely preserved; all that is left, upon decay are teeth and denticles.

The sampling, at this research site, was conducted on ten occasions with roughly 500 gallons of sediment being processed. I assume that the samples were large enough to produce a thorough example of the bone-bed's total species diversity and abundance at the macro-level. Diversity as well as abundance was greatest among the chondrichthyes; both measures were lower in the fish and crocodile fauna. Previous literature indicates turtle and reptile remains at this locality, but only a few reptile remains were found, including only one crocodilian tooth fragment and one turtle neural plate.

Listed below is a complete taxonomic list of fossil vertebrates found at Point "A" dam along with corresponding photographs of the teeth when available. If a selachian's species is heterodontic, and collections of more than one tooth from various positions in the mouth were obtained, all are photographed and grouped together.

Additionally, sampling was performed from the base of the bone-bed to the top of the exposure, in 30 cm increments, for a total of 3.5 meters (Figure A.3.); this collection was done to determine the vertical variation richness in this fossil exposure. The results support the initial hypothesis that the lag layer is confined to a zone roughly 15 to 20 cm in thickness. While some vertebrate material was found above the lag layer, the numbers of specimens decreased drastically and what was found was probably reworked material from the original bone-bed.

## Systematic Paleontology Table

### Sharks

Kingdom Animalia  
Phylum Chordata  
Class Elasmobranchii  
Order Carcharhiniformes  
Family Carcharhinidae  
*Galeocerdo* sp.

**Material**—108 teeth.

**Discussion**—Tiger shark (Figure C.1,G,I). Most common remain found at research site. Roughly 10 mm wide across the root and featuring a deep primary notch, with large serial cusplets along the distal edge of the serrated blade. Ideal for puncturing and tearing hard shelled prey, with its coarse serrations. The root has a transverse groove and a deep shoulder notch

Order Laminiformes  
Family Odontaspidae  
*Stiatolamia* sp.

**Material**—95 teeth.

**Discussion**—The extinct sand shark (Figure C.2.K) is the second largest group of remains collected at this site. The teeth are heterodontic and long and slender. Deep transverse root and lateral cusplets on either side of the crown. The teeth lack serrations and have no shoulder. The root is symmetrical and some of the teeth show a lip side curvation.

Family Lamnidae  
cf. *Isurolamna* sp.

**Material**—90 teeth.

**Discussion**—This tooth (Figure C.1.C) has a symmetrically shaped root with a transverse groove. The crown has a cusplet on either side of the crown which has a slight flat curvature to the tooth. The teeth lack serrations.

Lamna lerichei sp.

**Material**---35 Teeth

**Discussion**—These anterior mackerel teeth (Figure C.1.D) have very solid and substantial roots. The small cusplets are present on both sides and the teeth are not serrated.

Family Odontaspidae

*Brachycarcharias lerichei*

**Material**—31 teeth.

**Discussion**—The sand tiger shark (Figure C.1.E) is small in size, lack serrations, has cusplets and a transverse groove in the root. This is a very seldom seen species.

Family Mitsukurinidae

*Anomotodon novus*

**Material**—16 teeth.

**Discussion**—The extinct goblin shark (Figure C.1.J) has an asymmetrical root without cusplets and no serrations. The crown curves slightly away from the lip. Some of the teeth show a transverse groove while others do not.

Order Carcharhiniformes

Family Carcharhinidae

*Abdounia recticonia*

**Material**—15 teeth.

**Discussion**—The extinct grey shark (Figure C.1.B) are smaller teeth with a pronounced transverse groove, a crown that curves slightly and two to three cusplets on either side of the crown. The root is generally asymmetrical with relation to the transverse groove.

Order Lamniformes

Family Odontaspidae

*Hypotodus* sp.

**Material**—12 teeth.

**Discussion**—The extinct mega tooth sand shark (Figure C.1.H) has an asymmetrical root with a transverse groove and one cusplet on either side of the curving crown.

Order Orectolobiformes  
Family Orectolobidae  
*Squatiscyllium* sp.

**Material**—11 teeth.

**Discussion**—The wobwgong shark (Figure C.2.Q) is a rare extinct tooth that has crown that rises off a flatten root that protrudes in the opposite direction as the crown. It also has an indented ridge in the root and two cusplets on either side of the crown that is blunt.

*Nebrius* sp.

**Material**—10 teeth.

**Discussion**—The nurse shark (Figure C.2.M) is a semi rounded curve protruding from a simple unobtrusive root. The curve of the arch of the crown is lined with deep serrations and no real lead crown point.

Order Squatiniformes  
Family Squatinidae  
*Squatina* sp.

**Material**—5 teeth.

**Discussion**—The angel shark (Figure C.2.O) teeth are small with a root is more bulbous with a deep transverse groove. The teeth look very similar to dermal denticles and have a crown with a cusplet on either side.

Order Orectolobiformes  
Family Orectolobidae  
*Eometlaouia* sp.

**Material**—1 tooth

**Discussion**—There is no common name for this shark and it resembles the *Squatoscyllium* sp. tooth and looks very much like a dermal denticles.

Order Carcharhiniiformes  
Family Carcharhinidae  
*Physogaleus secundus*

**Material**—1 tooth.

**Discussion**—The extinct sharp-nosed shark (Figure C.1.F) is only 4mm big and has a more round crown than flat; it has one very small cusplets on either side and a small transverse groove.

*Carcharocles auriculatus*

**Material**—1 tooth

**Discussion**—The megalodon predecessor (Figure C.1.A) is a large tooth, 50mm long, with deep serrations and double cusplets on either side of its flat grooved crown. The root is symmetrical and lacks a transverse groove.

Order Henanchiiformes  
*Hexanchidae* sp.

**Material**—1 tooth.

**Discussion**—The extinct blunt nosed six gilled shark (Figure C.2.L) looks similar to a cow shark tooth. It possesses a descending row of crowns that decreases in equal amounts as it goes to termination. The entire tooth is 5mm long and the crowns are 1.5mm in length and decreases to less than 1mm over five crowns.

**RAYS:**

Superorder Batoidae  
Order Myliobatiformes  
Family Myliobatidae  
*Leidybatis* sp.  
Eagle Ray (Figure C.2.R)

*Rhinoptera* sp.  
Cow Nose Ray

*Aetobatus* sp.  
Spotted Eagle Ray

*Myliobatis dixonii*  
Eagle Ray (Figure C.2.P)

Family Dasyatoidae  
*Coupagezia* sp.  
Devil Ray (Figure C.2.S)

Order Rajiformes  
Family Rhinobatidae  
*Rhinobatos* sp.  
Shovel nose Ray

**FISH:**

Class Osteichthyes  
Order Pristiformes  
Family Pristidae  
*Pristis* sp.  
Sawfish (Figure C.2.N)

Family Dercetidae  
*Cylindracanthus rectus*  
Swordfish

Family Trichiuridae  
*Trichiurides* sp.  
Extinct Cutlass fish

Family Phyllodontidae  
*Egertonia* sp.  
Drum fish

Family Scombridae  
*Sphyraena* sp.  
Barracuda

*Acanthocybium* sp.  
Kingfish

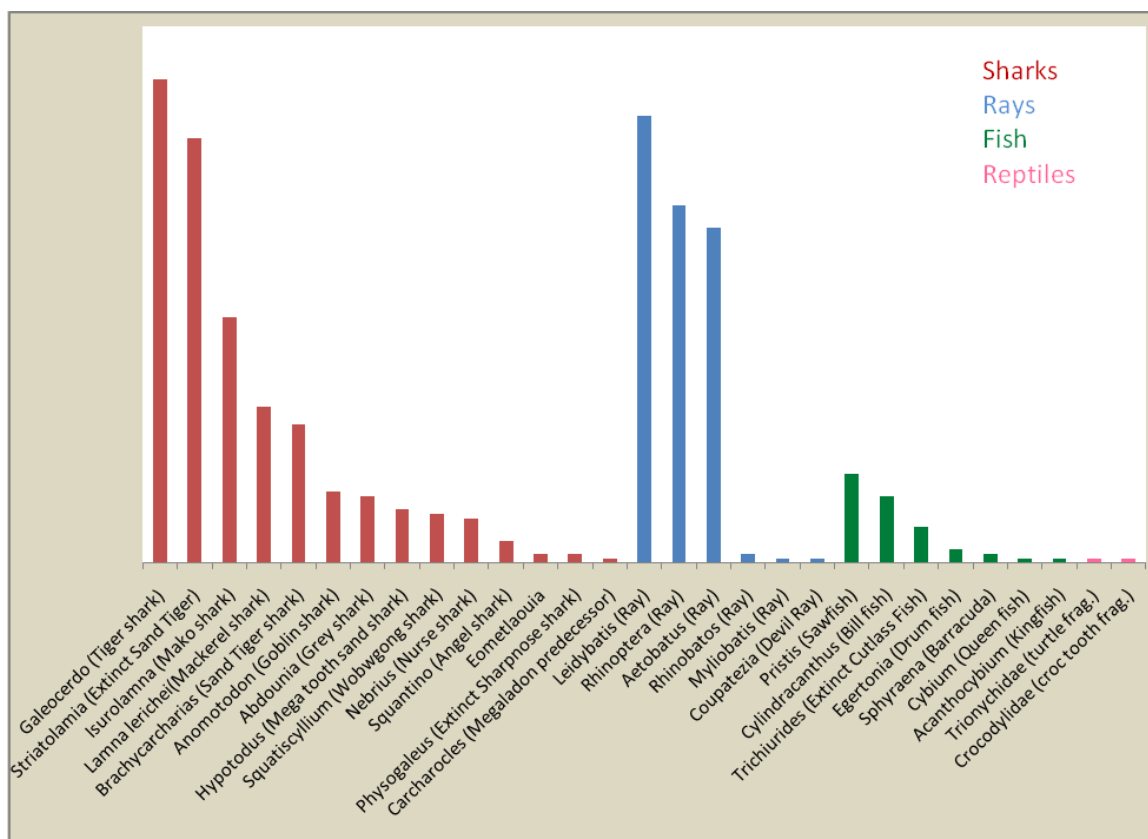
*Cybium* sp.  
Queen fish



**REPTILES:**

Super class Tetrapoda  
Class Reptilia  
Order Testudines  
Family Trionychidae  
Turtle Neural cranium fragment

Order Crocodylia  
Family Crocodylidae  
Crocodile tooth fragments



**Figure 19.** Faunal diversity vs. abundance at Point “A” dam to the Genus level.

## **VIII. Bone-beds**

Point “A” Dam bone-bed contains primarily marine fauna; however, the Holman, A.J., and Case, G.R., 1988 research shows some terrestrial components can be found at this locality. This project produced no terrestrial fauna and saw only vertebrate marine remains. The lag layer, found at this site, has not been classified as a bone-bed and very little literature has been written on the fossil remains that are exposed during low water levels. According to Rogers et al. (2007), a bone-bed is a sedimentary stratum that preserves the hard parts of more than one individual organism in a confined spatial region. In this project, that contained zone was roughly a 6-8 inch zone directly atop the ichnofacies of the upper most part of the Tallahatta Formation. It also falls into the microfossil bone-bed criteria as the majority of the samples (bioclasts) collected are less than 5 cm in dimension.

This bone-bed is dominated by fishes with chondrichthyan dental elements forming the largest portions of all bioclasts. Teeth are the hardest parts of these organisms which lends themselves to preservation. The teeth found at this research site are remarkably pristine given their origin during the Mid-Eocene. They have very little abrasion on their surface, and most teeth were found fully preserved. This type of preservation indicates that the teeth were not aggressively reworked after deposition and most likely deposited in a low energy estuary setting.

## **IX. Conclusion**

This research has provided insight into the vertebrate/phosphate lag layer found at Point “A “ Dam and spillway, along the Conecuh River just north of River Falls, Alabama. The results support the following conclusions:

1. The exposure along the Conecuh River has not been previously delineated stratigraphically. This investigation shows that the Tallahatta Formation and Lisbon Formation are both exposed, and at low water levels their interface can be easily observed. These two formations have previously been interpreted as being conformable. However, this research shows that the two are distinguishable at this locality and they are separated by an unconformity.
2. Data collected from systematic sampling indicates that chondrichthyes and osteichthyes (fish) dominated the fauna with only a few specimens falling outside these two classes. Chondrichthyes specimens outnumbered the osteichthyes by a ratio of 15 to 1. Diversity, when analyzed by genera, indicate that selachians rank as the most abundant, followed by batoids. Boney fish represent the least abundant vertebrate taxa in terms of diversity.
3. The south-central part of Alabama, during the middle Eocene, was a warm tropical sea. The sediments exposed at the research site were most likely deposited in an estuary. The high concentration of glauconite indicates that there was a strong influx of terrestrial sediments. Such an environment would have supported the fauna found at this locality.

4. The southern region of Alabama was subject to multiple transgressive and regressive cycles during the Middle Eocene. The uppermost portion of the Tallahatta Formation and the lowermost portion of the Lisbon Formation represent a transgressive period of deposition.
5. Previous research at this site has been limited. The Geological Survey of Alabama has little to no information on the exposed fossiliferous lag layer exposed at Point “A” Dam. Some small scale collection and research has been performed at this locality, however, no one has discussed this site and its fossil containing layer as a bone-bed. The observations performed in this research indicate that this deposit conforms to the definition of a bone-bed; It has the faunal content of many organisms and the fossil content is sufficiently greater than the background matrix.

## **X. Future Work**

Future work should be conducted at Point “A” dam and the surrounding counties to find the lateral extent of this bone-bed. Much of the geology that has been conducted in the southern part of Alabama has not involved coring and thus very little is known of the subsurface stratigraphy in this region. It is my belief that this bone-bed extends beyond this research area. Fully defining its extent may lead to a more thorough description of Alabama’s paleoecology during the middle Eocene.

Furthermore, a microscopic examination of the faunal remains found at this locality may lead to a richer understanding of the taxa diversity. The work conducted in this thesis was strictly macro-to-mesoscopic and this approach may have reduced the abundance and diversity found at this research site. Also, an investigation into the organisms that produced the trace fossils would add to the interpretation of the depositional environment since some organisms are representative of specific habitats.

Additionally, an analysis of the nannoplankton, diatoms, and foraminifera at Point “A” dam may further support the demarcation of the Tallahatta and Lisbon formations. Figure 20 displays the nannoplankton zonation that could be applied to future investigations into these micro-organisms and their correlation to the formations discussed above.

As mentioned earlier in this report, little work has been conducted on the lateral extent, sequence stratigraphy, and lithological differences of these two formations. A thorough examination of the two formations and further work would aid in defining the Claiborne Group more accurately.

Epoch	Stage	Group	Zone	Lithostratigraphic Units						
				Texas	Louisiana	Mississippi	Alabama	North Carolina		
EOCENE	Late	Jackson	NP 21	Whitsett	Yazoo Clay	Yazoo Clay	Yazoo Clay	Yazoo Clay	New Bern FM.	Sequence 4
			NP 19/20	Manning					Sequence 3	
			NP 18							
	Middle	Bartonian	Claiborne	NP 17	Caddell	Moody's Branch	Moody's Branch	Moody's Branch	Castle Hayne Limestone	Sequence 2
				Yegua	Cockfield	Cockfield	Gossport			
				NP 16	Cook Mountain	Cook Mountain	Cook Mountain	Upper Lisbon	Sequence 1	
	Early	Ypresian	Claiborne	NP 15	Sparta	Sparta	Kosciusko	Middle Lisbon	Sequence 0	
					Weches		Zilpha Shale	Lower Lisbon		
				NP 14	Queen City	Cane River	Tallahatta	Tallahatta	Unnamed Subsurface	
					Reklaw					

**Figure 20.** Nannoplankton zonation for Texas, Louisiana, Mississippi, and Alabama.

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**Appendix A:** Photographs of research site.



**Figure A.1:** Research site with collection sites "X", "Y" and "Z" generally located.





**Figure A. 2:** Initial collection site at the northern most section of the outcrop.





**Figure A. 3:** Vertical sediment collection site “X”, taken at 30 cm intervals, to show vertical extent of bone-bed.





**Figure A. 4:** Sedimentary cores that were removed from site “X”

**Appendix B:** Total counts for species abundance and diversity.

<b><u>Taxon</u></b>	<b><u>Total</u></b>
Galeocerdo (Tiger shark)	108
Striatolamia (Extinct Sand Tiger)	95
Isurolamna (Mako shark)	55
Lamna lerichei(Mackerel shark)	35
Brachycarcharias (Sand Tiger shark)	31
Anomotodon (Goblin shark)	16
Abdounia (Grey shark)	15
Hypotodus (Mega tooth sand shark)	12
Squatiscyllium (Wobwgong shark)	11
Nebrius (Nurse shark)	10
Squantino (Angel shark)	5
Eometlaouia	2
Physogaleus (Extinct Sharpnose shark)	2
Carcharocles (Megaladon predecessor)	1
Leidybatis (Ray)	100
Rhinoptera (Ray)	80
Aetobatus (Ray)	75
Rhinobatos (Ray)	2
Myliobatis (Ray)	1
Coupatezia (Devil Ray)	1
Pristis (Sawfish)	20
Cylindracanthus (Bill fish)	15
Trichiurides (Extinct Cutlass Fish)	8
Egertonia (Drum fish)	3
Sphyraena (Barracuda)	2
Cybium (Queen fish)	1
Acanthocybium (Kingfish)	1
Trionychidae (turtle frag.)	1
Crocodylidae (croc tooth frag.)	1

**Table B.1.** Collection totals from all three collection sites

## Appendix C: Vertebrate Remains Plates

----- = cm

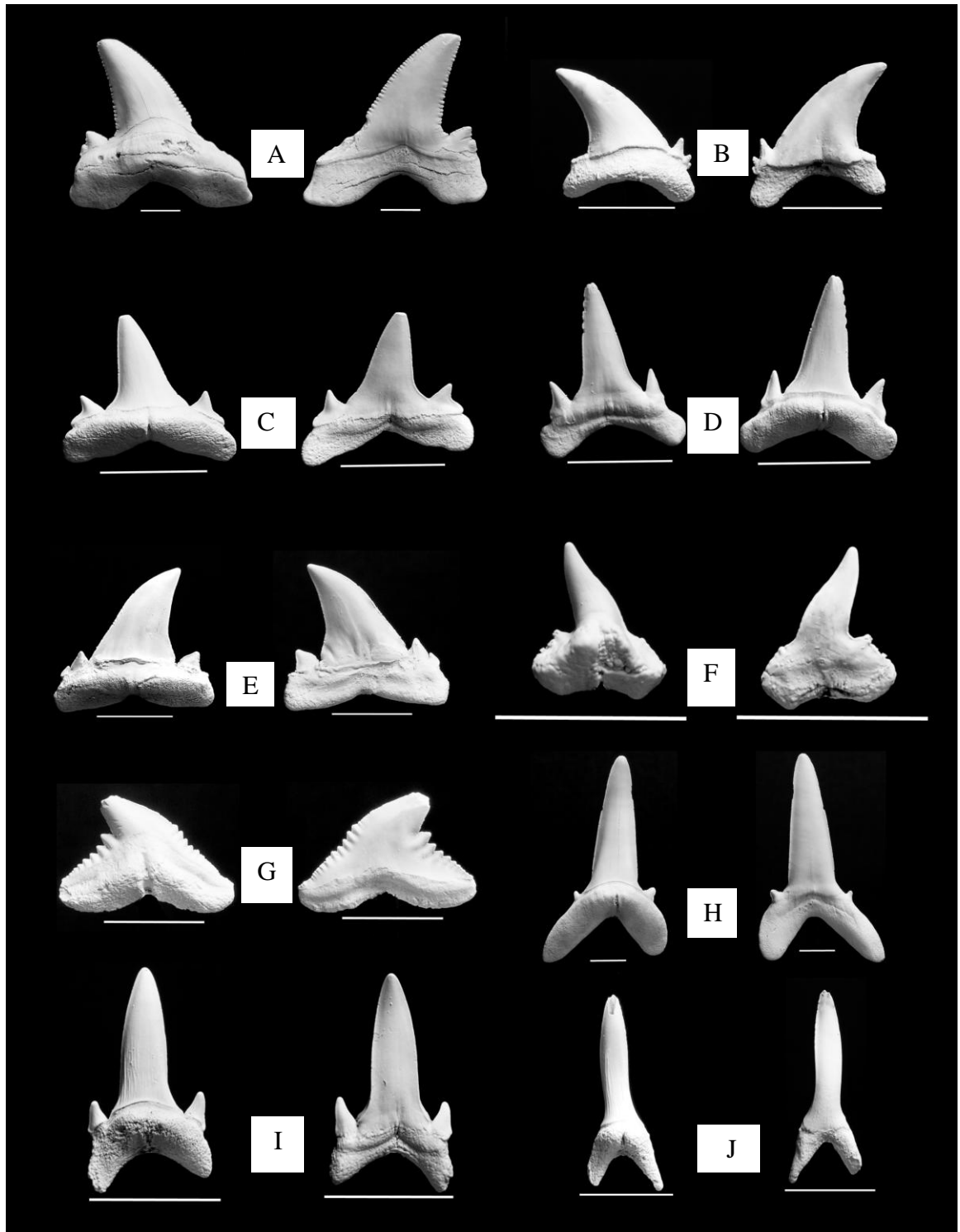
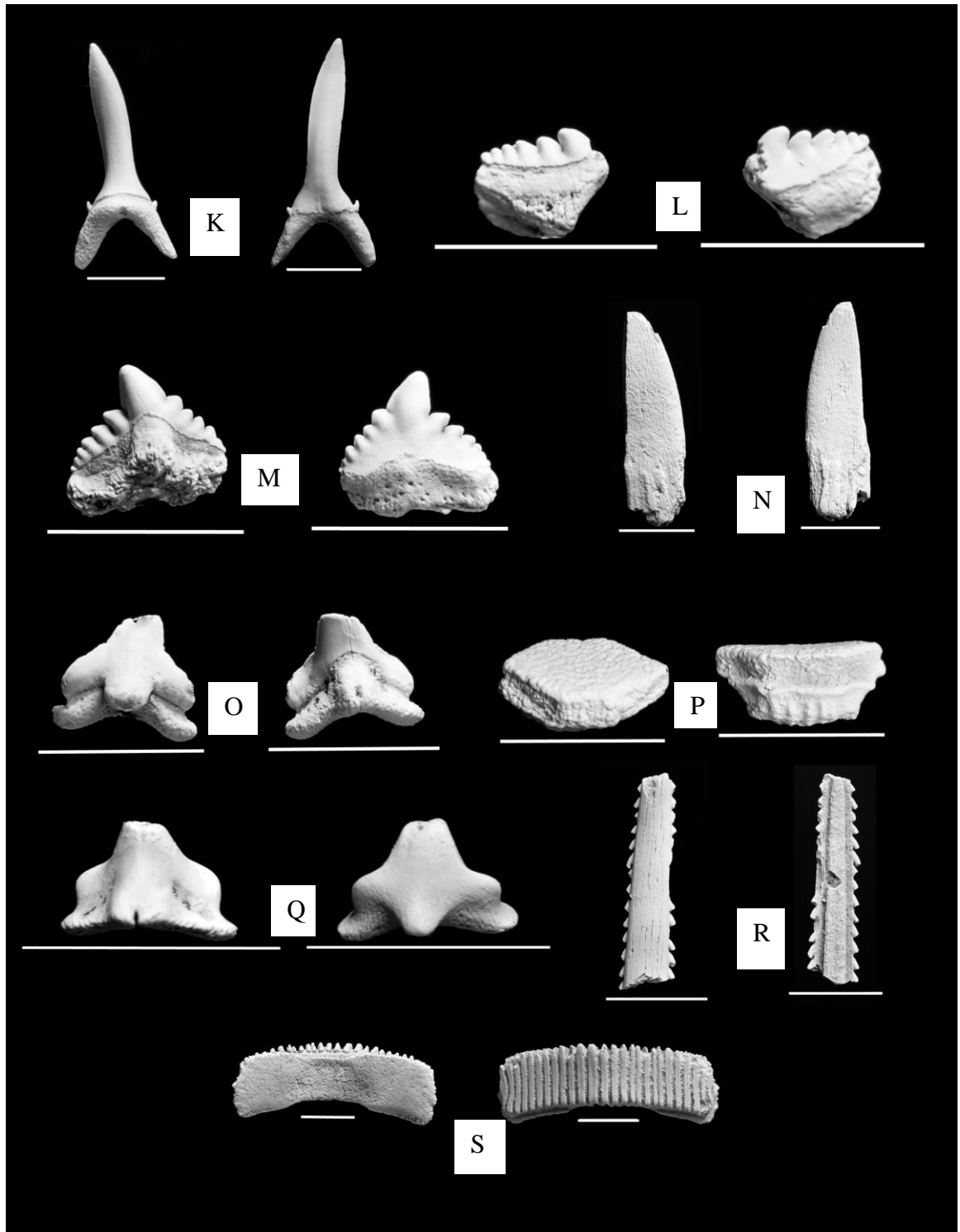


Figure C.1. (A-J)



**Figure C.2. (K-S)**